National Aeronautics and Space Administration

ROLE OF LOW-COST MISSIONS
in preparing for human Mars Exploration

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Intended Audience: Low-Cost Science Mission Concepts for Mars Exploration Workshop

Presentation Objectives: ideas for how low-cost science missions can enable eventual human Mars exploration

MEPAG SCIENCE GOALS TO ENABLE HUMAN MARS EXPLORATION

A. Inform Entry, Descent, and Landing (EDL) risks for human-scale landers

B. Inform Extravehicular Activity (EVA) risks

C. Inform In Situ Resource Utilization (ISRU) opportunities

D. Inform planetary protection risks/ops

E. Inform Phobos/Deimos exploration risks and opportunities

Refer to Mars Exploration Program Analysis Group (MEPAG) goals: https://mepag.jpl.nasa.gov/reports/MEPAGGoals_2020_MainText_Final.pdf

MARS EXPLORATION PROGRAM ANALYSIS GROUP (MEPAG)
GOAL IV OBJECTIVES: PREPARE FOR HUMAN EXPLORATION

A	**Inform EDL Risks**	**A1.** Aspects of the atmospheric state that affect orbital capture/EDL for human scale missions
		A2. Characterize orbital debris environment around Mars
		A3. Assess landing-site characteristics and environment related to human-scale landers.
B	**Inform EVA Risks**	**B1.** Assess risks to crew health/performance from (1) ionizing radiation, (2) possible toxicity of martian dust
		B2. Characterize surface particulates that could affect performance/life of hardware
		B3. Assess climatological risk of dust storms in the human exploration zone
		B4. Assess landing-site characteristics/environment related to safe operations and trafficability
C	**Inform ISRU Opportunities**	**C1.** Understand resilience of atmospheric In Situ Resource Utilization systems to martian environment
		C2. Characterize potentially extractable water resources to support ISRU for long-term human needs
D	**Inform Planetary Protection Risks**	**D1**. Determine martian environmental niches that meet definition of “Special Region” at exploration zone
		D2. Determine if martian environments to be contacted by humans are free of biohazards
		D3. Determine if martian materials or humans exposed to environment can be certified free of biohazards that might have adverse effects on the terrestrial environment and species if returned to Earth
		D4. Determine the astrobiological baseline of the human landing site prior to human arrival
		D5. Determine survivability of terrestrial organisms exposed to Mars (characterize forward contamination risk)
E	**Inform Phobos & Deimos Explora-tion Risks and opportunities**	**E1.** Understand the geological, compositional, and geophysical properties of Phobos or Deimos sufficient to establish specific scientific objectives, operations planning, and any potentially available resources.
		E2. Understand conditions at the surface/low orbital environment so as to design an operations plan

The following are *examples* of relatively low-cost partnership ideas that could help us whittle away at Goal IV

A1, A3 | B3, B4

NEXT-GENERATION INGENUITY

WHAT: Remote-controlled aerial scout

- Bonus features: bigger payload capacity/longer time of flight

WHY: assess ability to support various contingencies or crew risk mitigations

- Deploy communications relay to a terrain high-point
- Local weather assessment: real-time dust or wind conditions aloft to support critical crew ascent or landing decisions
- Emergency aerial illumination
- Rapid point-to-point small object delivery
- **Science bonus**: local, high resolution contextual data could support surface operations

A1, A3 | B2, B3, B4

WEATHER STATIONS

WHAT: More Weather Stations in More Locations

- Bonus feature: if combined with Ingenuity, could deliver a weather station to a high terrain point
- Bonus feature: include radiation monitoring

WHY: we'll need to understand weather all the way to the ground (and how to forecast it) for Entry, Descent, Landing, and Ascent planning

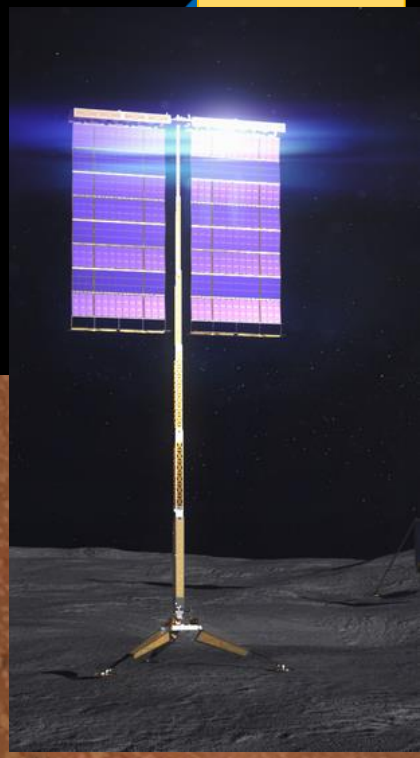
- Science Bonus: a network of monitoring stations could foster better understanding of Mars' climate

B2, B3

SOLAR POWER DEMONSTRATOR

WHAT: Solar Power Test Rig

- Bonus feature: multiple test rigs, with different types of arrays or different types of dust removal schemes, some potentially derived from Artemis lunar applications



WHY: we've got data on fixed solar panels on rovers, but other configurations, dust mitigation materials or mechanisms could improve reliability

- Science Bonus: power available from each rig can be used to power science experiments

IMAGE CREDIT: https://mars.nasa.gov/insight/weather/

LONG DURATION WITNESS PLATES

WHAT: Mars-equivalent of the Long Duration Exposure Facility (LDEF), in orbit and/or on surface

- Witness plates with various spacecraft and space suit materials exposed to the surface environment
- *Note: best if combined with in situ robotic materials assessment capability*

WHY: if we pre-deploy equipment before crew arrives, we need to be sure the environment won't degrade materials

- **Science Bonus**: micrometeoroid data, possibly planetary-protection tie-in's

A2	B1, B2	D3	E2

A3 B3, B4

RETRO REFLECTORS

MARS PERSEVERANCE RETROREFLECTORS

WHAT: more retro-reflectors in more places

WHY: support future laser-based instrumentation, navigation/landing aids

- Science Bonus: laser-based science instruments

A1, A3 | B2, B3, B4

AROUND-THE-CLOCK LIVE STREAM

WHAT: stationary camera streaming continuous, high-resolution video

- Bonus feature: night-vision, multiple cameras, pan/tilt
- *Note: only possible with supporting communications infrastructure*

WHY: to help us train the first human visitors to Mars

- Enables integrated comm system reliability assessments
- Live-stream from Mars can serve as a “virtual window” for a Mars analog mission on Earth
  - Adds realism, lets us analog how the view will change with season, sunlight, dust storms, or time of day
- **Science Bonus**: we may capture environmental phenomena we’ve never seen before, because we just weren’t looking

There are a number of relatively simple potential add-on's to Mars science missions that would enable future human exploration

Questions?

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